

LUBRICATION

A Technical Publication Devoted to the Selection and Use of Lubricants

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Power Plant Steam Cylinders

PRESENT-DAY steam conditions involving pressures up to around 1800 pounds, and superheating to an ultimate temperature of some 780 degrees Fahr., have presented an entirely new conception to the theory of power plant steam cylinder lubrication. Steam has made a definite bid for continuation as a primary source of power. It is making this bid in terms of improved heat transfer by means of higher pressures and temperatures.

Steam cylinder lubrication is in turn protected by reduction of oxidation of cylinder oils through deoxidizing of the steam and make-up feed water. This procedure also protects the boiler tubes and steam lines against corrosion.

We are, therefore, concerned with factors of far greater importance today, in the selection of cylinder oils, than when we were primarily interested in highly saturated steam, and moisture was our chief problem.

Obviously, we must still remember that the use of steam as a medium of power generation will involve a number of requirements from the viewpoint of lubrication, which are normally foreign to the operation of any equipment except the reciprocating steam engine, steam pump or compressor. Pressure, temperature and moisture must all be considered, for each will have a decided influence upon effective lubrication.

Furthermore, whether or not exhaust steam is to be used for process heating purposes, returned to a feed water heater or "just wasted" must also be taken into account, for use of an excess of cylinder oil and its presence in exhaust steam may cause trouble in open systems where

perishable goods such as textiles may be involved. If returned to the boilers, on the other hand, certain lubricating constituents may give rise to deposits on tube surfaces, blistering and subsequent failure.

Function of the Lubricant

A steam cylinder oil must lubricate every sliding surface which is either in direct contact with the steam, or subject to its pressure and temperature. Engine design as it involves steam valves, valve rods, slide valve seats, cylinder walls, pistons, piston rings, piston rods and throttle valves, must therefore be carefully considered. These parts are not always subject to the same pressure and temperature conditions, yet the one oil must serve throughout, and, therefore, it must be sufficiently flexible in operation to produce efficient lubrication wherever necessary.

Valve Design

Steam valve design has a decided influence upon the performance of a cylinder oil, so we must understand the details of the four types of valves in use today:

1. The slide or D-valve,
2. The piston valve,
3. The Corliss, and
4. The poppet valve.

The Slide or D-valve

The common slide valve is one of the most difficult to lubricate due to inequalities of pressure and the consequent suction or "wiping" action which it exerts upon the lubricated

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valve seat. Therefore, the oil film must be continuously renewed, otherwise ineffectual lubrication may result, with cut or worn valves and seats. This can normally be detected by jerky motion of the valve stem which is caused by momentary sticking of the valve to the seat.

The Piston Valve

With the piston valve, on the other hand, the steam pressure is balanced, and as a result there is less tendency for the oil to be squeezed or wiped from the valve seat. As a result, piston valve engines can operate under considerably higher pressures than slide or Corliss valve engines.

The Corliss Valve

The Corliss valve is a slide valve to the extent that it is subject to sliding action on its curved seat. There is not as great an area of contact as in the D-valve, however, hence, although it is subject to unbalanced steam pres-

As a result, individual feeders for the lubricant are usually installed at such points.

Poppet Valves

While valves of this type are reciprocating in action, they are not subject to sliding on the valve seat. As a result, lubrication at this point is relatively unnecessary. Poppet valves are also balanced as to steam pressure; hence they are capable of operation under higher pressures, the same as piston valves.

Poppet valves require lubrication of the stems only. It is essential, however, to regulate the flow of lubricant carefully and to guard against an excess, otherwise abnormal carbonization of the oil will occur and the valves will stick.

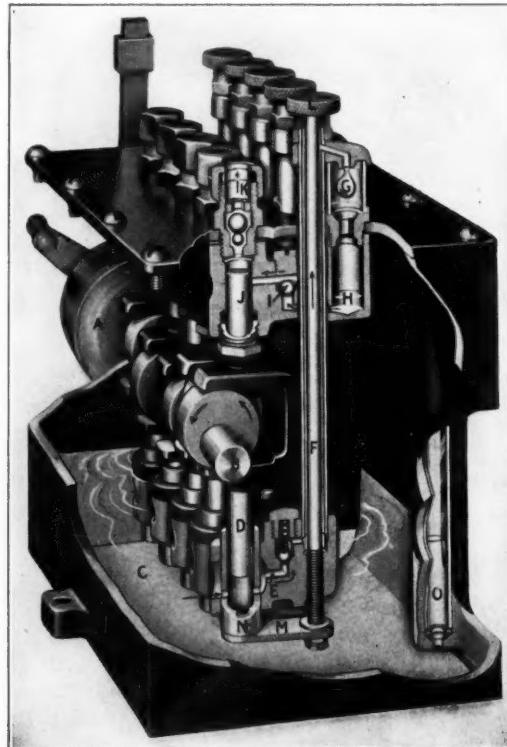
ENGINE DESIGN

In the horizontal engine, steam pump or compressor steam cylinder lubrication must be studied with respect to the load developed by the weight of the piston and rod, especially at the out-board end. This weight is obviously carried by the lower part of the steam cylinder unless a tail rod is provided. On account of this weight the piston may tend to wear the bottom of the cylinder out of round; consequently, unless sufficient lubrication is provided, the clearance between the piston and the cylinder may become so great as to cause serious leakage of the steam past the piston. In addition, the pressure upon the oil film may be increased to such an extent as to cause it to fail. This will be aggravated if the rings are sharp on the edges and scrape the oil film off the surface of the cylinder walls. Because of these conditions a cylinder oil for such service must have characteristics which will provide a heavy lubricating film and it must be used in sufficient quantities to maintain same. Even with the most efficient oil a certain amount of wear will take place and the rings will have to be renewed occasionally. Fortunately, however, all the above will be offset to some extent by inertia losses which counteract the weight of the piston.

Engines having heavy pistons and rods are often provided with tail rod supports, which, together with the cross head, carry the weight of the former. In such engines the only pressure on the cylinder walls is that developed by the tension of the piston rings and the pressure of the steam which has worked its way in back of them. This will usually permit the use of a thinner film of oil delivered at a reduced rate. Furthermore, oil will tend to flow down to the bottom of the cylinder where it is needed most.

Vertical Cylinders

In contrast, the weight of the piston, piston rod, cross head and connecting rod are carried



Courtesy of S. F. Bowser & Company, Inc.

Fig. 1—Details of the Bowser Model "T" force-feed lubricator showing the various pumping mechanisms. Arrows show direction of rotation of the cam device which operates the pumps, likewise the flow of oil from pump base "N" via check valves, through "F", "H" and "I" to outlet "K". Rate of flow is controlled from adjusting point "L".

sures, this type of valve can function under higher pressures than the former. The chief difficulty with a Corliss valve is to maintain a suitable film of lubricant at the end of the valve.

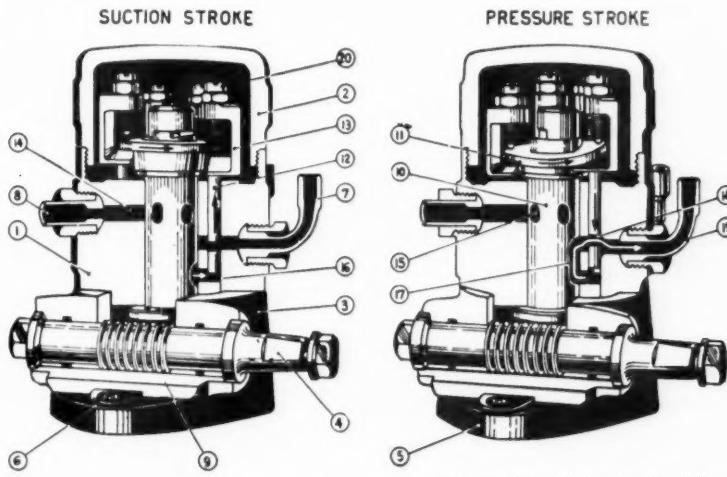
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by the crank pin in the vertical engine. This facilitates lubrication, as the only pressures on the cylinder walls are those due to the tension of the piston rings, the steam which has worked

polished or glazed; this improved surface condition lends to reduced friction.

Rod and Stuffing Box Lubrication

It is obvious that valve, piston and tail-rods will operate most effectively in their respective stuffing boxes when the contact surfaces are properly lubricated. It is usually considered the duty of the cylinder oil to lubricate these latter; one must never forget, however, that detrimental results may occur if they are neglected. So even though such rods will generally receive sufficient lubrication from the oil in the steam, it is frequently customary to install auxiliary sight feed oil cups or make some other provisions for external oiling of the rods. As they are very accurately machined and ad-



Courtesy of United American Bosch Corp.

Fig. 2—A Bosch Type MRD oiler showing: 1, Lubricator body; 2, Screw Cap; 3, Lubricator Base; 4, Drive Shaft; 7, Oil Outlets; 8, Suction Inlet; 9, Worm; 10, Pump Shaft; 12, Pumping Plunger; 13, Pumping Plunger Head; 15, Radial Bore Holes; 18 Oil Passage; 19, Outlet Nipple.

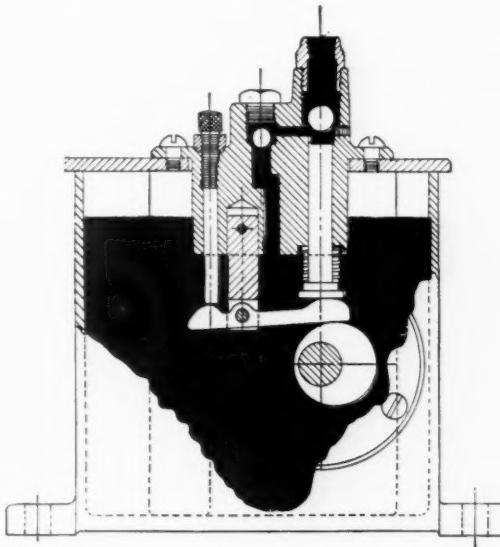
round in back of them, and possibly the forces developed by side motion.

In such engines the rings must function with uniform spring over their entire surface of contact with the cylinder walls. They must, therefore, be accurately set, and just tight enough to prevent any abnormal steam leakage. A film of oil thick enough to prevent excessive friction between these rings and the cylinder walls, and enough oil to maintain this film, especially over the upper surfaces of the walls, are all that is required to provide proper lubrication. The selection of oil is based on the same principles that govern the oil used for horizontal cylinders, though the quantity required will probably be reduced, and somewhat less compound will be necessary.

One even goes so far in marine service as to frequently do away with cylinder lubrication. Here it is assumed that the water in the steam will serve as the lubricant. This is an advantageous procedure where the condensed steam is used as make-up boiler feed, and where adequate oil separation may be impracticable. The rate of wear may be higher, but at any event it will be less objectionable than oil in the condensate.

In the vertical marine engine the space rings and piston usually have water grooves to hold a small amount of condensed steam which serves to decrease steam leakage, making it possible to use looser fitting rings and consequently decreasing the friction. After a short time, these cylinder walls become highly

adjusted, any overheating due to lack of lubrication might cause a change in alignment, with ultimate damage to the internal mechanism of the engine.



Courtesy of Hills-McCanna Company
Fig. 3—The Hills-McCanna Model "ET" type "BF" lubricator which employs a single plunger and ball valves to take oil from the reservoir, measure it and force it to the delivery point.

CHOOSING THE CYLINDER OIL

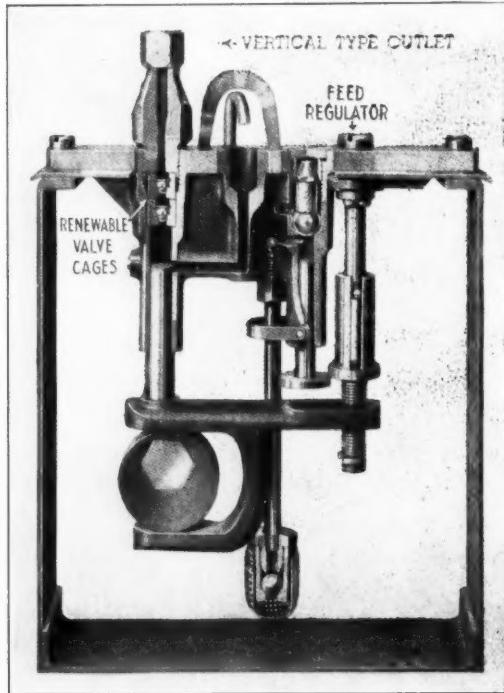
In considering the operating conditions in the average industrial plant to which a steam

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cylinder oil may be subjected, one must realize the relation which exists between—

Pressure and temperature.

The effect of temperature and velocity on atomization.



Courtesy of Manzel Brothers Company

Fig. 4.—Pumping unit of the Manzel Model 25 force feed lubricator showing arrangement of plungers and valves, etc.

The moisture content of the steam.

The degree of superheat, and

The use which is to be made of the exhaust.

Relation of Pressure to Temperature

Steam pressure must be associated with temperature. As a result, the usual operating temperatures in the steam cylinder and valve chest must be taken into consideration when we are selecting the initial characteristics of a cylinder oil. In other words, viscosity will be decreased as steam temperatures are increased. Therefore, where operating with high temperature saturated or superheated steam a heavier bodied oil should be used. Conversely, where steam pressures are low, or where a partial vacuum with accompanying low temperatures exist, a lower viscosity, more easily atomized oil is necessary. Filtration lends to more ready atomization.

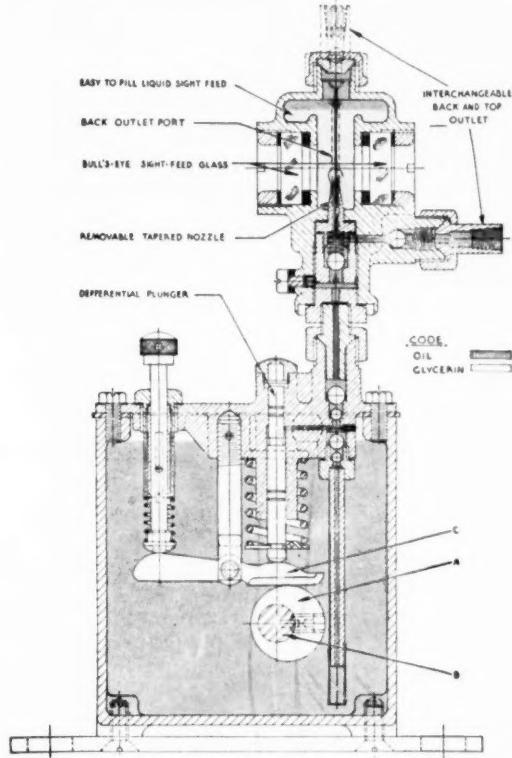
High Flash Point not Essential

Under average operating temperatures the effect of heat upon the actual chemical behavior of the oil in the engine will normally

be negligible, viz., "the operating temperature" for saturated steam at, say, 600 pounds will be 486.6 degrees Fahr. This is below the open cup flash point of any cylinder oil. Furthermore, it is probable that the flash point would be raised with increased pressure. As a result, there does not seem to be any reason for the common belief that a very high flash or fire test is necessary. Saturated steam always contains moisture and as there is relatively little oxygen present in the steam to support combustion, it does not seem likely that ignition could be produced in the cylinder, regardless of the flash point of the oil.

Atomization Improved by Steam Velocity

Atomization of a cylinder oil is improved as the velocity and temperature are increased. In other words, the higher the temperature and velocity the more readily will a heavy bodied oil be atomized, due to the reduction in vis-



Courtesy of McCord Radiator & Mfg. Company

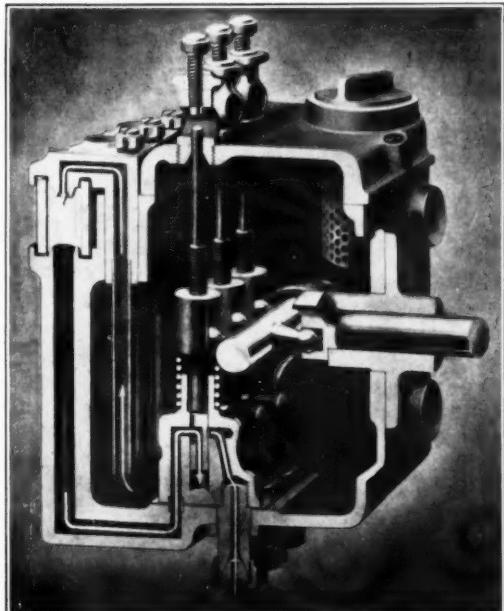
Fig. 5.—Showing details of the McCord Class "SF" lubricator. "A" "B," and "C" indicate respectively a hardened cam fixed on an operating shaft engaging with a rocker arm which is attached to the pump unit. Other parts are indicated as shown.

cosity which occurs at the temperature of atomization. Obviously, these conditions must therefore be taken into account when deciding on the initial viscosity of the oil.

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How Moisture Affects the Lubricating Film

Steam will always contain a certain percentage of moisture unless it is superheated to a sufficient extent to counteract any lime and



Courtesy of Nathan Mfg. Company

Fig. 6—Sectional view of the Nathan Mechanical Lubricator type "DSI" as designed for steam cylinder lubrication. In this device no check valves are employed but the pistons are oscillated and reciprocated, thereby controlling the intake and discharge ports. This movement is obtained by a horizontal sliding shaft actuated by an eccentric through the operating lever of the ratchet and some reciprocating part of the engine.

cylinder condensation, which may be caused by the cooling effect of the piping or cylinder walls, and the expenditure of heat by the expansion stroke. The presence of moisture in steam will usually result in a film of straight mineral lubricating oil being rapidly washed off from the cylinder walls and other surfaces with which the steam comes in contact. Therefore, to secure proper lubrication under wet steam conditions it is necessary to either increase the rate of flow of the straight mineral oil, or else substitute an oil which contains a certain percentage of fatty compound such as lard oil, degras or tallow.

Such compounds develop an emulsion through their reaction with the moisture in the steam. The lubricating film thus has a greater affinity for the cylinder walls and other wearing surfaces and becomes highly resistant to the washing action of the water in the steam. Naturally the greater the percentage of moisture in the steam the higher should be the fatty compound content of the lubricant. In general, the compound should not exceed 10 per cent.

however, except in extreme cases of abnormally wet steam.

An excessive amount of fatty compound, beyond that necessary to form the requisite emulsion, will not improve the lubricating value of the oil. In fact, it may even be an objection, especially under continued exposure to high temperatures, on account of the tendency that animal fats have to decompose.

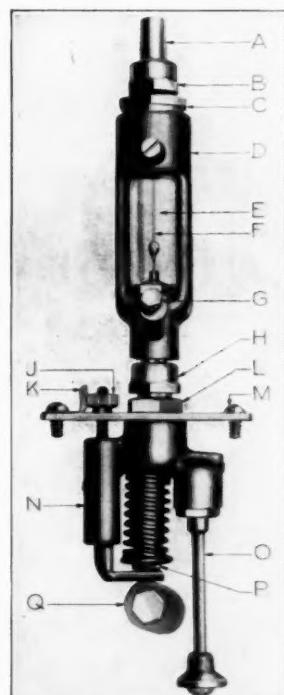
Choosing the Compound

In other words, it should always be the maxim to use only just enough compound to conform to the moisture conditions of the steam and maintain a suitable film of oil on the cylinder walls. This is especially true where the exhaust steam is to be used for feed water heating or in process work of any nature. Under such conditions it is more important than ever to observe caution in selecting and using steam cylinder lubricants. Today, the petroleum industry seeks to reduce the quantity of compound and to improve its quality.

The Detriments of Compounding

That tendency in compounded oils which causes them to unite with water to form emulsions in the cylinders also prevents ready separation from water in condensed steam; likewise, the more completely the oil is atomized the more difficulty will it have in separating from water. Obviously this will cause trouble where the condensate is used for makeup, or led to open feed water heaters.

Oil in the form of fine emulsions in a boiler combines with the boiler compounds to cause foaming, or with the boiler impurities to produce a coating over the tubes and fire surfaces. This coating seems to form more readily over clean tubes than over dirty ones. A very thin layer of oily sludge over a



Courtesy of Madison-Kipp Corporation

Fig. 7—The Madison-Kipp SVH pumping unit. "A" is the outlet tailpiece; "B" and "C" the coupling and clamp nuts; "D" and "E" the sight feed; "F" the oil guide wire; "G" a vent plug for starting. The pumping unit details shown at "N" include a suction tube "O"; a plunger "P"; and cam "Q" for plunger action.

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tube or shell surface will so insulate it that there is not only a large loss in heat efficiency, but the rise in temperature of the metal may be so excessive as to cause burning out or explosion of the boiler.

Even if exhaust steam is used only for heating, the heaters may become coated with oil and lose in efficiency. This is also true if exhaust steam is used in tube and shell feed water heaters. Likewise, if the engines are of the condensing type, unless removed the oil will form layers on the condenser tubes with consequent loss of vacuum and thermal efficiency.

When to Use Straight Mineral Oils

Straight mineral oil is used to lubricate wet steam only where the presence of a fatty oil in the exhaust steam is objectionable. As a rule, the increased amount necessary to insure proper lubrication will often result in imperfect atomization. In consequence, oil accumulations in the cylinder will be prevalent and carbon deposits developed. This will be especially true in multiple expansion engines equipped with receivers and re-heaters, the high temperatures to which the oil is subject being very conducive to carbonization.

Nature of the Oil

Steam cylinder oils must be of comparatively heavy body and have a particularly adhesive characteristic in order to insure the maintenance of a lubricating film which will resist the wearing or scraping effects of the average valve and piston, and washing off by the steam.

Viscosity or body is attainable by suitable refining; adhesiveness by judicious treatment of the cylinder stock and the addition of certain fixed or fatty animal oils. As a general rule it will be essential to use an oil having a viscosity range of between approximately 100 and 180 seconds Saybolt at 210 degrees Fahr., according to the steam pressure and temperature involved, the type of steam valves and the means of application available.

The Steam Lubricates Itself

The most efficient way of getting the lubricating oil to all desired points is to make use of the steam itself, which reaches all moving elements inside of the valve chambers and cylinders with the possible exception of parts of certain types of Corliss valves.

If the oil is divided into minute globules and intimately mixed with the steam, only a very small quantity is required, and the degree of success in the atomization of the oil will control both the efficiency of lubrication of the parts and the quantity necessary.

By Oil Atomization

The more complete the atomization and the

more thoroughly saturated all portions of the steam, the better will be the lubrication of all of the cylinder parts, and the more economical the consumption of oil. The degree of atomization of the oil is influenced by the condition of the steam, the point of introduction of the oil, the velocity of the steam, and the character of the oil.

Which is Promoted by High Pressure

Other things being equal, high steam pressure will produce quicker atomization of a given

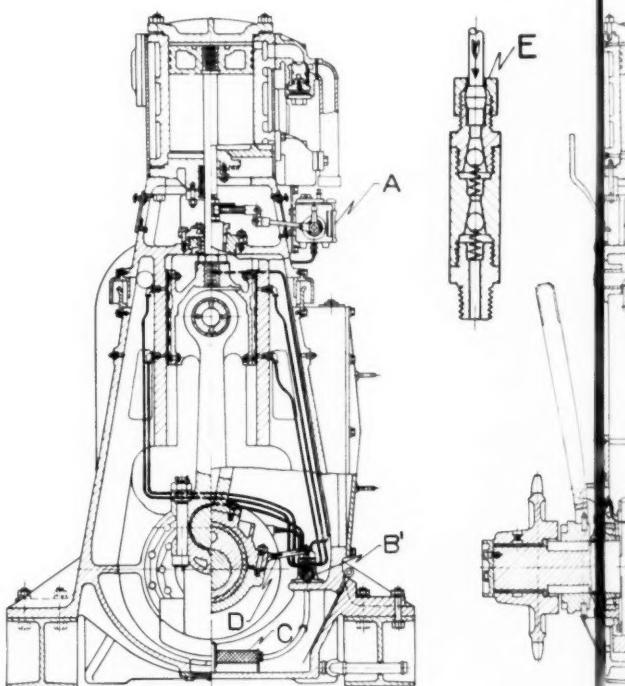


Fig. 8.—Showing an assembly of Nathan lubricators in vertical steam engine case, the piston valves and cylinders through the steam pipe, while one lubricator (labeled respectively "B" and "B'"), are mounted upon ledges over the oil sump in tank directly from the sump. Each lubricator derives its motion from one of the eccentric lines filled with oil at all times, a terminal check of the style shown at E should be.

oil than low steam pressure, since the attendant high temperatures thin down the oil to a greater extent; so, a comparatively heavy bodied oil may be atomized by a high pressure steam as quickly as a light bodied oil will be atomized by a low pressure steam. Conversely, low pressure steam requires a lighter bodied oil in order to obtain efficient atomization.

An oil, which has been filtered in the course of manufacture, in turn, will atomize more readily than an unfiltered product. Also, compounding with animal oils will tend to improve the atomizing ability of the average cylinder stock.

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Point of Introduction Important

If the oil is introduced directly into the valve chest or just above the throttle, a product must be used which will break up very quickly. On the other hand, if the point of introduction can be conveniently located from six to eight feet from the cylinder, it is possible to use a slower acting oil if other conditions render this necessary or advisable.

Further, if it is essential to use a heavy bodied oil to meet the cylinder conditions better lubrication may be secured at a more economi-

the lubricant will be quite considerable if there are any bends or other pipe fittings located between the lubricator and valve chest. In extreme cases under such conditions, it may often be necessary to install auxiliary direct-feed lubricators upon the valve chest or cylinder, even though an excess of oil may be used.

In multiple expansion engines equipped with receivers between the cylinders, the flow of steam may often be so checked as to cause the oil particles to be thrown down and deposited in the receivers. Where such is found to occur it will be advisable to install lubricators on each steam chest. The oil feed in such cases, however, should be carefully regulated, inasmuch as but little make-up lubricant is usually necessary to compensate for that lost in the receivers.

METHOD OF APPLICATION OF THE LUBRICANT

Steam cylinder oils can be applied directly to each of the separate wearing surfaces, or fed into the steam line between the throttle valve and the steam chest, the steam serving as an atomizing agent to carry oil to all moving parts therein.

Unit Lubrication

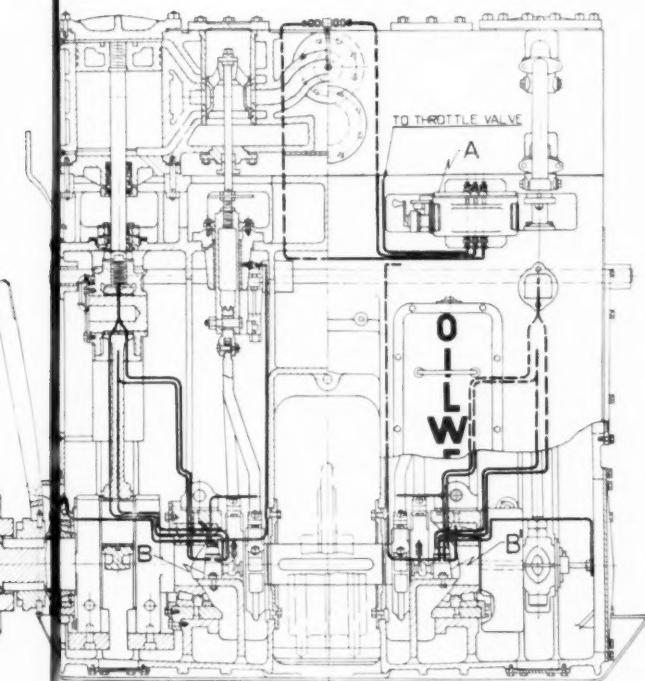
When the value of steam cylinder lubrication was first realized, direct application of steam cylinder lubricants by means of individual oilers installed on the valve chest and cylinder was considered satisfactory. It probably was under the prevailing pressure and moisture conditions. In brief, it involved feeding oil drop by drop into the engine, the lubricant being spread over the wearing surfaces by the movement of the valve and piston. Valve, piston and tail rod glands were often similarly equipped with drop feed oilers.

This method of lubrication was, and still is, suited to the single cylinder engine. It would be decidedly cumbersome and unreliable, however, if applied to a multiple cylinder unit, there are so many points requiring attention.

Pressure Lubrication

So when the multiple expansion engine came into service the theory of steam cylinder lubrication was revised to involve injecting oil by pressure into the steam line, using a hydrostatic or mechanical force feed lubricator.

Steam is the logical carrier for the oil, as it reaches practically all of the surfaces requiring lubrication in its passage through the engine, and thereby insures the transmission of the particles of oil which it carries to these parts. Sufficient oil, however, must be fed to the steam line and the point of introduction of the lubricant must be located at a suitable dis-



Courtesy of Nathan Manufacturing Company

engine case. The "DSI" Lubricator (See A) has three feeds, two being used for lubricating at the throttle valve. It turns two type "PSG" lubricators, each with eight feeds, marked P in the tank case. These take their oil through suction tubes C provided with strainers in them through its ratchet operating lever and a cross bar D. The oil lines leading from discharge against back pressure, such as cylinder feeds for instance, in order to keep the feed should be.

cal cost by placing the introduction of the oil further back from the cylinder.

When atomization is complete by the time the lubricated steam reaches the throttle valve, the latter will be quite as effectively lubricated and rendered capable of as efficient operation as the working parts of the engine.

If the point of introduction is located too close to the throttle valve or cylinder, complete atomization may not take place; if too far away there will be a possibility of the oil particles being thrown to the walls of the steam line, from whence a flow of liquid lubricant will occur to the valve chest. This condensation of

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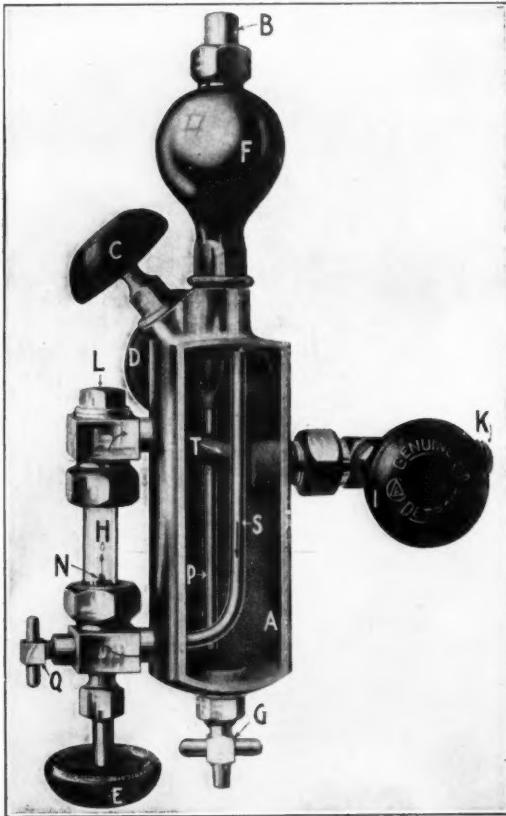
tance beyond the throttle valve and the steam chest to enable the steam to completely exercise its atomizing effect. If any of the oil is carried into the cylinder in liquid state its lubricating effect is lost, as it will either be swept out prematurely by the rush of exhaust steam, or be unable to distribute itself uniformly over the wearing surfaces.

TYPES OF LUBRICATORS

Analysis of the requirements of steam cylinder lubrication has led to the development of two basic types of lubricators, viz.:

1. The hydrostatic and
2. The mechanical force feed.

The former was probably the first application to employ pressure in handling steam cylinder oils. It was unique in that it used the pressure of the steam it was to lubricate.



Courtesy of Detroit Lubricator Company

Fig. 9—The Detroit hydrostatic lubricator for steam cylinder service. Steam admitted through pipe "B" and condenser "F" condenses to form a column of water which exerts pressure through tube "P" on the oil in "A". This forces oil through tube "S" and sight feed element "N" and "H" to the outlet elements "T" and "K".

Hydrostatic Working Details

In the hydrostatic lubricator the oil is forced drop by drop into the system by means of a head of water which is maintained by

condensing of the steam, so flow of oil is intermittent, drops being fed into the steam line at intervals, depending on the adjustment of the regulating valve and the viscosity of the oil. A heavy bodied oil will flow through the sight glass slowly in large drops, while a lighter bodied oil will feed in smaller drops at more frequent intervals; the latter gives more complete and uniform saturation of the steam.

When the oil does not feed properly, or if it runs up the side of the glass, the feed will be obscured due to discoloration. This is frequently caused by using a steam type of gauge glass. If it is not possible to get a proper glass, the size of the drop may be reduced by filing down the lip on the feed valve and soldering a fine wire to the latter to allow the oil to follow the wire. If the oil backs up in the sight feed glass, it is usually due to insufficient pressure difference. This condition may be corrected by increasing the distance between the two connections into the steam pipe.

There are also certain other details which may affect the dependability of the hydrostatic lubricator. For example, a change in temperature will affect the viscosity of the oil, the size of the globules fed, and consequently the regularity of the flow. In addition, the flow of oil will be independent of the speed of the engine, hence the cylinders will seldom receive exactly the correct amount of oil required by the operating conditions.

The Mechanical Force Feed Lubricator

This device was developed to overcome certain of the deficiencies of the hydrostatic lubricator. It is connected directly to some reciprocating part of the engine pump or compressor. Consequently oil is fed into the system at a rate which varies directly with the speed of operation.

The mechanical force feed lubricator functions only when the engine is operating, hence there is little possibility of wasted oil or flooding of the system. An efficient mechanical lubricator should feed the same amount of oil regardless of the temperature, viscosity or amount of oil in the reservoir.

Lubricators of this nature deliver a quantity of oil at intervals which may be regulated by adjusting the length of the plunger stroke or the time required to complete a stroke. A very short plunger stroke and a comparatively greater ratchet angle, results in small discharges at frequent intervals.

Control of Oil Temperature

When engines, and the steam ends of pumps or compressors are exposed to low temperatures, some provision should be made to keep the oil in the reservoir warmed up, otherwise it may

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become thick and cease to flow through the sight feeds to the plungers.

Pressure Conditions

Certain types of lubricators are unsuitable for compound condensing engines operating at a pressure below atmosphere in the low pressure cylinder, unless the check valves on the discharge side of the lubricator are spring loaded, as the low pressure may cause the oil to be drawn out of the reservoir into the cylinder in large quantities with great waste.

Methods of Oil Delivery

Steam cylinder oils must be thoroughly atomized to assure of complete dispersion through the body of the steam and ultimate deposition upon the valve seats and cylinder walls. The lubricator merely serves to feed the oil into the steam line; it is necessary to install a suitable atomizer which subsequently will insure effective breaking up of the oil before it enters the steam chest and cylinders.

Atomizers are only effective, however, provided that they are properly designed and installed. Faulty construction or careless installation may frequently defeat any possibility of satisfactory lubrication, and oil will be consumed in a relatively useless manner due to improper distribution.

Installing the Atomizer

This device should always be installed so that there are as few bends between it and the throttle valve as possible, as the steam, in striking the pipe at any bend, will throw out some of the oil onto the pipe where it may stick and run down the side.

If a steam separator is installed the oil should always be fed between the separator and the engine, otherwise the separator will remove a considerable part of the oil. Better atomization of any oil can be secured by feeding very small drops at frequent intervals than by feeding large drops less frequently.

A considerable amount of oil which is carried by the steam never comes in contact with the metal surfaces. On the other hand, it is very evident that far less oil will be wasted when it is completely atomized than when it is introduced directly into the cylinder or valve chambers by unit oilers.

The primary consideration is, of course, the efficient lubrication of the cylinders, walls and valve seats, and the oil should be selected with this in view. Then, if the point of introduction is not right to handle the oil selected, and if

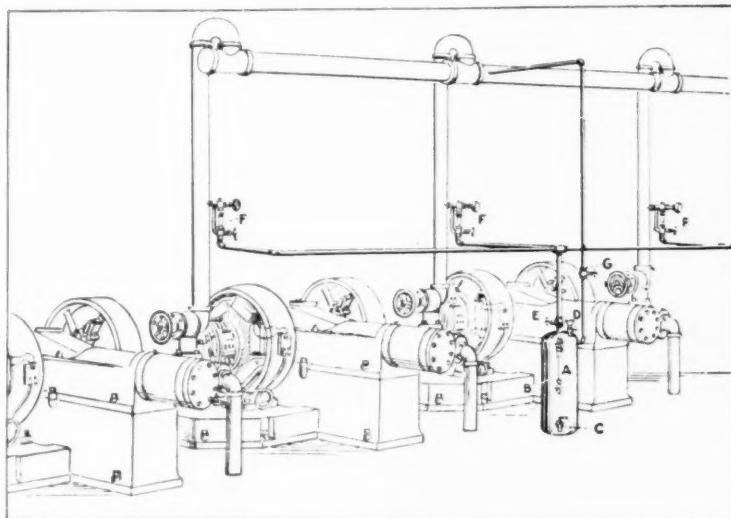


Fig. 10.—A central tank multiple feed hydrostatic steam cylinder oiling system showing the storage tank "A" and the respective lubricators at "F".

mechanical conditions will permit, it should be changed to enable subsequent atomization to as complete a degree as possible. Many times, however, it is not feasible to locate the atomizer at the correct point, and it becomes necessary then to compromise by changing the character of the oil, or adjusting the rate of delivery.

Manner of Installation

When inserting into the steam line, the topside center of the atomizer should be clearly and permanently marked for it is important that the outlets be directly lined up with respect to the travel of the steam; otherwise subsequent atomization will be impaired and the steam may be unequally lubricated.

One should always be careful to avoid installing the atomizer upside down, for under such conditions, relatively no atomization will occur, the oil simply dripping from the nipple. It is the action of the steam, impinging on the oil as it flows out along the exposed portion of this nipple and forcing it through the slots, which brings about the necessary atomization.

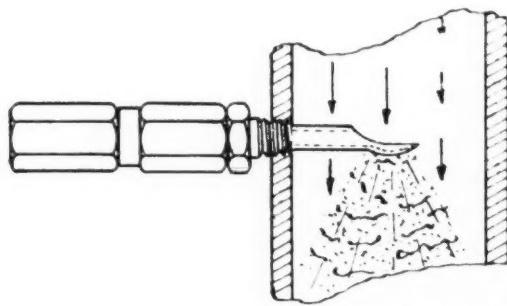
Types of Atomizers

Two types of atomizers are used today in power plant service. Each comprises a short length of pipe or a nipple inserted in the steam pipe, its outer end being connected to the lubricator delivery pipe.

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The Spoon Atomizer

This type is simply a piece of pipe or nipple of the same size as the lubricator discharge, and of such a length that when inserted in the steam pipe the tip will extend somewhat beyond the



Courtesy of Manzel Brothers Company

Fig. 11—An atomizer quill showing manner of dispersion of cylinder oil by the steam.

center line of the latter. Both ends of the nipple should be threaded; one end with a standard length thread, the other with a long enough thread to permit it to be screwed into the steam pipe as above.

The upper part of the long thread end of this nipple should be cut away on such an angle that the remaining section will have sufficient curvature to allow for the cutting of one or more slots parallel to the axis and from one to two inches long. The tip of this nipple should be bent to a spoon-shape, the slots preferably terminating at a sufficient distance from the end to insure against loss of rigidity.

The Perforated Atomizer

This type of atomizer has a number of perforations instead of slots in the nipple. In this case, the nipple is usually not cut away, but remains intact, being drilled uniformly along the top and bottom (with respect to the axis) over perhaps a distance of two-thirds to three-quarters of the steam pipe diameter, with a sufficient number of equally spaced $\frac{1}{8}$ " to $\frac{1}{4}$ " holes. The top holes should preferably be somewhat enlarged.

The nipple may or may not be threaded over its entire length according to the way it is to be installed and attached to the lubricator fitting. Some engineers find it advisable to weld or plug up the end of this nipple which is inserted into the steam line. Others carry it through to the opposite side of the steam pipe.

The perforated atomizer should be quite as carefully installed as the spoon-shaped device, and every care should be taken to see that the holes are directly in line with the direction of flow of the steam in order that the latter may blow through and carry the oil out in a spray.

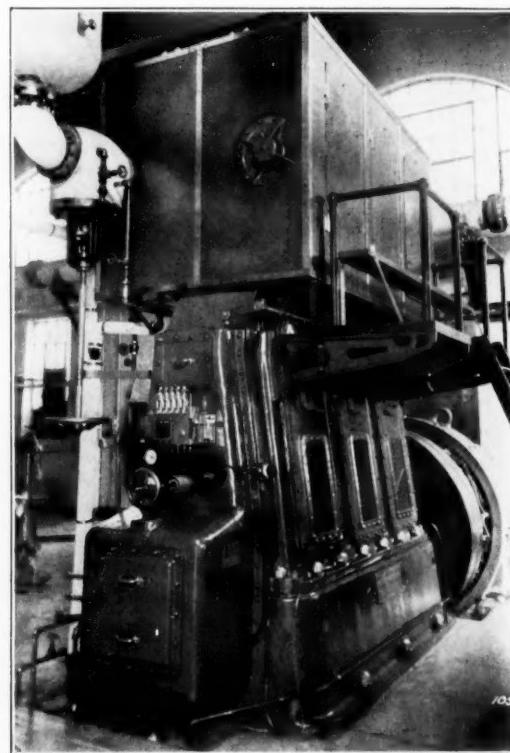
If by chance, such an atomizer is so installed

that the perforations point towards the walls of the steam pipe, the steam may not pass through, and atomization will not be effected. In this case, the atomizer will simply become an oil dripping device. Atomizers of this type are not always effective even when properly installed due to the possibility of the holes becoming plugged up.

Another type of perforated atomizer has holes drilled in the top of the nipple only, the steam making a turn and carrying the oil out through the end. In its installation the same care should be exercised as above.

Modified Types

While the above are the only practical types of steam cylinder oil atomizers in use, others may consist of an open ended nipple, or a nipple drawn down to an orifice, and inserted into the steam pipe so that the oil just drips out into the steam. Whether much atomization actually occurs when oil is thus allowed to drip into a



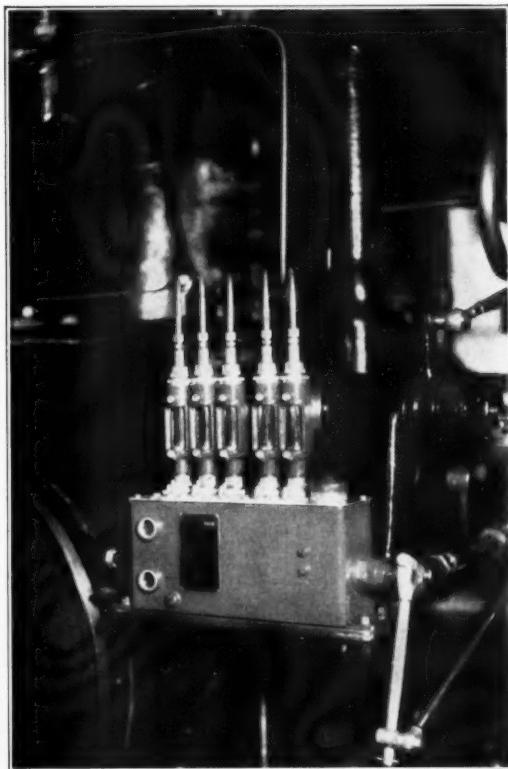
Courtesy of Manzel Brothers Company
Fig. 12—A Manzel 5-feed Mod. 191, ratchet drive lubricator installed on a 3-cylinder vertical Skinner Uniflow engine.

volume of high velocity steam is often a question. Frequently the drops of oil will be swept to the walls of the pipe to simply run down perhaps as far as the throttle valve.

LUBRICATION

SUPERHEAT CONDITIONS

Superheated steam will be chiefly confined to prime mover service. From a lubrication viewpoint one must consider not only the comparatively high initial temperatures, but



Courtesy of Madison-Kipp Corporation

Fig. 13—Installation view of a Madison-Kipp lubricator serving a cross compound superheated steam engine, via five outlets to the steam line and piston.

also the possibility of indeterminate moisture conditions due to condensation during a portion of the expansion stroke and over the entire exhaust stroke. In other words, superheated steam seldom prevails throughout the engine. So unless there is approximately 200 degrees initial superheat at the throttle practically no superheat will be left in the steam at the exhaust. Consequently, instead of a purely superheated steam condition, we will have a dual problem to study in the selection of the most suitable steam cylinder oil, viz., initial superheat with subsequent saturation or moisture conditions. The one oil must be capable of meeting both.

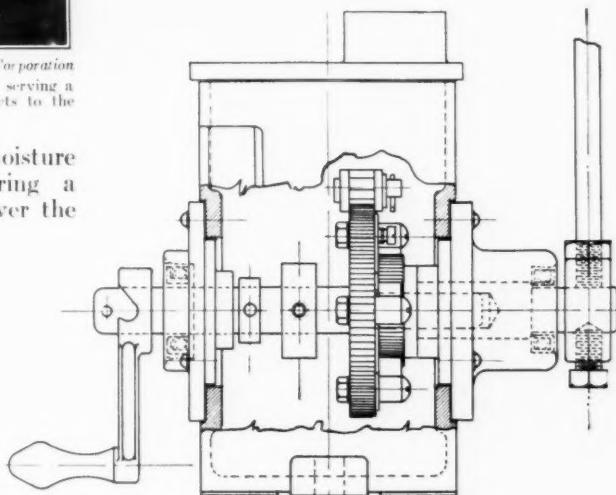
Carbonization

The initial temperatures are the cause of

most of the trouble encountered in the lubrication of superheated steam cylinders. Whenever air may be present the usual heats involved may cause carbonization of some oils, and deposits on the valves at the end of the valve travel and at the end of the counterbore in the cylinders. Carbon deposition also will be accelerated by feeding an excess of oil to the cylinders. Carbonization is regarded by some authorities as being caused primarily by air, although it is accelerated by the oil remaining in contact with the hot surfaces and exposed to superheated steam long enough for its lighter hydrocarbon constituents to be evaporated and the oil partially decomposed.

If the lubricant were of such characteristics that it evaporated more readily and if it were fed to the cylinders in such small quantities that an accumulation of oil would not develop on the valves and other parts of the engine, carbon deposits could be entirely eliminated.

Many engineers consider it necessary, however, to use an excess of oil (over the amount they would use with saturated steam) whenever they are lubricating steam cylinders by straight mineral oils. Oils of this nature are usually of high viscosity and have high flash and fire points. Since they are lacking in compound they are suitable for the lubrication of the cylinder only as long as the steam remains dry or superheated; they cannot be depended upon to lubricate during that portion of the stroke when the steam is saturated, due to the



Courtesy of Hills-McCanna Company

Fig. 14—Cross section of the Hills-McCanna ratchet drive.

fact that the subsequent moisture washes the oil off the cylinder walls to cause the latter to become dry. This will result in wear and increased friction.

L U B R I C A T I O N

Consequently, the engineer will be prone to increase the rate of feed, so that something like satisfactory lubrication is secured, and in doing so, such a large amount of oil may be fed to the cylinders that it will not all be carried away.

The problem therefore becomes one of selecting an oil to meet the operating conditions. It is normally felt that a medium-heavy viscosity cylinder oil, having a fair amount of compounding, say perhaps 4 to 5 per cent prime lard oil or tallow, will be best. The resultant oil, on account of this compounding, will emulsify when necessary and thereby lubricate the cylinders very efficiently during that period when they are filled with saturated steam. As the per cent of compound is low no ill effects should result from exposure of the oil to superheat conditions.

This is somewhat contrary to the usual understanding as to the properties necessary for an oil to withstand superheated steam, but the success which has attended the use of this type of oil makes the above explanation seem to be most reasonable and logical. Furthermore, it will give the most dependable lubrication, and when sparsely applied should develop a minimum of objectionable residues.

INDICATIONS OF EFFECTIVE LUBRICATION

The condition of the wearing or contact surfaces in any engine, steam pump or compressor furnishes the best evidence as to how protective the lubricating film may be. This will be indicated by:

- The film of oil on the piston rod.
- The amount of oil in the condensate, and
- The action of the valves.

Since time is necessary for the lubricating film to form and function properly a hasty decision as to the suitability of such an oil should never be made. Any test should, therefore, cover a period of several weeks. Then the engine should be shut down and the cylinder head and valve chest cover removed to enable inspection of the interior. If there is evidence of a film of lubricant sufficient to penetrate and leave the time-honored brown-

ish stain on three or four thicknesses of cigarette paper the surfaces may safely be regarded as being sufficiently lubricated. If below this film they appear highly polished and of a color varying from bright iron-white to steel-blue they have been properly lubricated.

When Faulty Lubrication Occurs

This will be indicated by the surfaces being rough, dry, dull in appearance or rusty. Under such conditions lubrication has either been insufficient or the wrong grade of oil has been used. In addition, if the stain on the cigarette papers appears streaked, blackish or mottled, either the oil has been subject to carbonization or abnormal wear has taken place. Lack of lubrication will also sometimes be indicated by sticky valves or groaning sounds from the cylinder, when the engine is running. With Corliss valve systems slowness in action of the dash pots will likewise be an indication of impaired lubrication.

Exhaust Steam an Indicator

The exhaust or condensate is oftentimes a good indicator of the extent to which cylinder and valve lubrication is being maintained. If the condensed steam shows considerable quantities of liquid oil, either too much oil is being fed or it is not properly atomized. If it shows minute drops of oil and is milky in color it is probable that atomization is complete and the feed is correct. If the piston rod shows a film of oil on it and there is no oil fed directly thereto it can be taken as an indication that the atomization is satisfactory, or at least that the surfaces are receiving sufficient oil.

Excessive lubrication on the other hand, will be indicated by pools of oil lying in the bottom of the cylinder or in the counterbore. This can only be determined, however, at the time of engine overhaul.

A suitable film on the piston rod, minute drops of oil and a milky appearance in the condensate, free action, and little or no noise in valve operation, are indications that the oil is suitable, atomization complete, and the rate of feeding correct.